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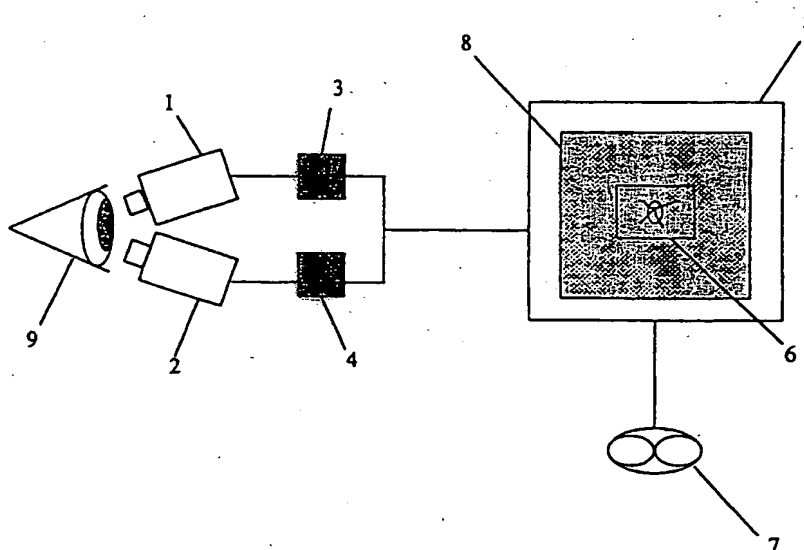




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/AU98/00863 <b>(22) International Filing Date:</b> 15 October 1998 (15.10.98) <b>(30) Priority Data:</b> PO 9819 15 October 1997 (15.10.97) AU <b>(71) Applicant (for all designated States except US):</b> THE LIONS EYE INSTITUTE OF WESTERN AUSTRALIA INCORPORATED [AU/AU]; 2nd floor, 2 Verdun Street, Nedlands, W.A. 6009 (AU). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> EIKELBOOM, Robert, Henry [AU/AU]; The Lions Eye Institute of Western Australia Incorporated, 2nd floor, 2 Verdun Street, Nedlands, W.A. 6009 (AU). YOGESAN, Kanagasingam [AU/AU]; The Lions Eye Institute of Western Australia Incorporated, 2nd floor, 2 Verdun Street, Nedlands, W.A. 6009 (AU). VAN SAARLOOS, Paul, Phillip [AU/AU]; The Lions Eye Institute of Western Australia Incorporated, 2nd floor, 2 Verdun Street, Nedlands, W.A. 6009 (AU). <b>(74) Agent:</b> GRIFFITH HACK; 509 St. Kilda Road, Melbourne, VIC 3004 (AU).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>

(54) Title: STEREO OPTIC DISC ANALYSER



## (57) Abstract

The present invention provides a system for creating and visualising three-dimensional images of an object, including imaging means for obtaining two images of the same object from different angles, digitizing means for digitizing the images, image processing means for colour matching and registering the images, controller means for converting the two images into an interlaced image, display means for displaying the registered interlaced image, and visualizing means for visualizing the image in three dimensions. It also provides a method for creating and visualising three-dimensional images of an object including obtaining two images of the same object from different angles, digitizing the images, colour matching and registering the images, converting the two images into an interlaced image, displaying the registered interlaced image for visualizing the image in three dimensions, measuring areas of interest, and calculating desired measurements of the object.

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## STEREO OPTIC DISC ANALYSER

5 The present invention relates to a computer imaging or  
vision technique for the creation and analysis of three  
dimensional images, of particular but not exclusive  
application in the creation and analysis of images of the  
retinal wall of the eye, and in other three dimensional  
10 medical and industrial imaging, including fields such as  
plastic surgery or aerial surveying and mapping. The  
invention also has application in the detection of  
anomalies of the ocular fundus, and in the early diagnosis,  
treatment and observation of diseases such as glaucoma and  
macular degeneration.

15 The ability to visualize objects in stereo, or in three  
dimensions, is a function of the position of the organs of  
sight, the eyes, and the manner in which the human brain  
processes visual information. The eyes are offset from one  
20 another, resulting in a slightly different view of an  
object being presented to each eye. The brain 'combines'  
the left and right perspectives, such that a single image,  
conveying information about depth, is perceived. Unlike  
the eye, conventional imaging methods, such as slide, film  
25 and video images, present only two dimensional images of an  
object.

The ocular fundus and optic disc possess, like most  
objects, a three dimensional structure. A better  
30 appreciation of fundus topography can, therefore, be gained  
from stereo photography and stereoscopic viewing. Stereo  
fundus photography can create three dimensional images of  
the optic nerve head. Using a fundus camera, the  
photographer produces two images of the ocular fundus, from  
35 the perspective of his or her left and right eye. The two  
images must then be aligned, and viewed with a stereo slide  
viewer, or a light table coupled with a pair of plus (+)  
lenses. Alternatively, the images may be projected through

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a polarised material onto a screen, with the stereo pair polarised at 90° to each other. The observer must view the images through polarising glasses with a polarising filter in front of each eye. These devices enable the left and right eye to "see" its corresponding image so that a stereo representation may be perceived (see Saine & Tyler (1997) for an overview of stereo imaging techniques).

Stereo examination of the ocular fundus provides useful information about the health of the eye, to guide diagnostic and treatment decisions. However, the clinician is most interested in observing the evolution of fundus topography over time. Comparing a patient's stereo fundus photographs at regular intervals may allow the clinician to review subtle changes in the architecture of the optic nerve head. However, these images, often taken at different times, by different people or in different lighting conditions, may possess variable characteristics, in terms of magnification, colour and the positioning of features in the image. These variations in image quality could be mistaken for changes in the topography of the optic nerve head.

Computer technology can overcome some of these problems through the use of image processing techniques. Colour matching techniques can eliminate colour and tonal differences between images of the same object taken on separate occasions, while image registration can minimise scale, translation and rotation variation. Regular computerized imaging of the ocular fundus is, therefore, a useful ophthalmic technique, enabling the clinician to make diagnostic decisions, track the course of a disease and to measure the effectiveness of treatment.

A number of digitized systems of image analysis have been developed to aid in the quantitative analysis of stereo images, such as that illustrated in US Patent 5,519,485.

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This patent describes a computerized, stereo image, measuring apparatus, suitable for topographical mapping and capable of displaying, and varying the magnification of, stereo images, and performing measurements relating to the three dimensional structure of the object being imaged. A control device or central processing unit controls the function of this system. Left and right images are introduced, from a scanner or the like, into two separate optical disc drives. Images are displayed on a high resolution, stereo, display device comprising; a left and right monitor, a half mirror, a polarizing filter in front of each display unit and orthogonal polarized glasses worn by the observer. A feature extractor may be used to extract features from the image data through designated left and right measuring points.

US Patent 5,270,924 describes an ophthalmic image processing system that is able to recognize the difference between the left and right images of a stereo pair and to distinguish the top and bottom of the images, so that they may be stored without confusion. Another image processing system, the IMAGEnet, from Topcon Corporation, comprises a computerised image processing system for fluorescein angiography pictures, and fundus photography. This system may digitally enhance stereo images using sharpening and contrast stretching tools. Analysis functions, such as line area measurement, enable quantitative analysis of a number of separate images. However, this product has proven to be somewhat impractical in a clinical setting, as it requires long processing times and only registers images for translation differences in the X and Y directions.

Heidelberg Engineering have also developed a method of imaging the fundus of the eye, using software which captures images from a confocal scanning laser ophthalmoscope (CSLO). A CSLO image is constructed from a series of "slices" taken at varying levels of the fundus.

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Th slices are "stacked" together to form a singl  
representation of fundus topography, with an accompanying  
sense of volume. To allow analysis of the sam region of  
interest on respective slices, the operator defines this  
5 region with a contour line. This defined area then is  
stored and aligned on subsequent images. A topographical  
representation of the fundus is produced by determining  
height measurements at each location on the cSLO's multiple  
captured images. Estimates are then made of topographic  
10 variables, such as the mean height of the fundus contour,  
the optic cup volume and the volume of the optic nerve rim.

Quantitative analysis in the Heidelberg system is based on  
the intensity of the light reflected from the fundus. The  
15 area of highest reflectance is equivalent to the fundus  
contour, the edge surrounding the optic nerve head. At  
each level, or slice, the edge or fundus contour is  
determined, creating a topographic map of the fundus and  
enabling the calculation of the clinically important values  
20 outlined above. However, if a lesion or vessel in the  
slice is more reflective than the contour, the position of  
that lesion will be considered the position of fundus  
contour, a situation which may result in a misleading  
topographical picture.

25 Current computerised stereo imaging systems, such as those  
outlined above, may suffer from a number of practical  
disadvantages. Difficulties with image registration  
challenge the accuracy of analysis, while long processing  
30 times are a problem for clinical practice. Many of these  
systems produce only monochrome images which do not convey  
as much information as full colour images. In addition,  
none of the presently available systems provide a  
comparative measure for reviewing, in real time, three  
35 dimensional imag s in rapid sequence. There remains a need  
for an imaging system capable of producing full colour,  
registered, stereo images in real time. A novel, stereo



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imaging method and apparatus has therefore been developed, for constructing a three dimensional view of an object, and for performing quantitative analysis of the resultant stereo photographs. The present invention enables images of a three dimensional subject, such as the ocular fundus, to be viewed in stereo, and for serial comparison to take place between colour matched and registered images of the same object.

It is therefore an object of the present invention to provide an improved imaging system capable of producing a virtual, three dimensional representation of an object, that also enables an observer to compare representations of the object taken at different times.

It is a further object of the present invention to provide an improved stereo image processing system which has the ability to colour correct and automatically or semi-automatically register images in a stereo pair, or a set of stereo pairs, compensating for differences in size, rotation and translation between the stereo images.

According to the present invention there is provided a system for creating and visualising three dimensional images of an object, including:

imaging means for obtaining two images of the same object from different angles;

digitizing means for digitizing said images;

image processing means for colour matching and registering the images;

controller means for converting the two images into an interlaced image;

display means for displaying the registered interlaced image; and

visualizing means for visualizing the image in three dimensions.

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Preferably the system includes measuring means for measuring areas of interest in three dimensions, and calculating means for calculating desired measurements of the object.

5

Preferably the system includes a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

10

Preferably the stereo flicker chronoscope is operable to serially display stereo pairs or sets of stereo pairs,

The stereo pairs or sets of stereo pairs may have been registered and/or colour corrected, by means of the image processing means.

15

The measuring means may be a three dimensional cursor.

Preferably the calculating means includes computer software.

20

Preferably the system includes result display means for displaying the results of the measurements.

25

Preferably the result display means is a polar graph centred on the optic nerve head.

30

Preferably the imaging means is a stereo camera, a digital camera, a digital stereo camera, a video camera or a scanning laser ophthalmoscope operable to record two different views of the object to be imaged.

35

Preferably the digitizing means is a image scanner operable to digitize a slide film with high resolution, a digital camera, or any other apparatus operable to produce an image in, or convert an image into, a digital format.

Preferably the controller means is a computer or

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microproc ssor.

Preferably the image processing means is software using the techniques of colour matching and image registration,  
5 and/or includes means for changing image magnification in three dimensions and real time.

Preferably the display means is a video display monitor or the like.

10

Preferably the visualizing means includes a pair of Liquid Crystal Display goggles.

The present invention also provides an apparatus for  
15 viewing three dimensional images of an object, including:  
    imaging means for obtaining first and second images of a stereo pair;  
    digitizing means for digitizing the two images;  
    image processing means for determining and correcting  
20 for colour, rotation, translation and scale differences between different images of the same object;  
    controller means for converting the images into a stereo interlaced image;  
    display means for displaying registered interlaced  
25 images; and  
    visualizing means for visualizing the images in three dimensions.

Preferably the apparatus includes measuring means for  
30 measuring specific characteristics of the object,  
calculating means for calculating desired measurements of the object and result display means for displaying the results of measurements.

35 Preferably the apparatus includes a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

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Preferably the stereo flicker chronoscop is operable to serially display stereo pairs or sets of stereo pairs.

- 5 Preferably the measuring means includes a three dimensional cursor.

Preferably the measuring means includes a circular or elliptical template that may be superimposed over each  
10 optic disc, and which may be used to measure one or more parameters including neuro-retinal rim width and optic disc cupping.

Preferably the calculating means includes computer  
15 software.

Preferably the first and second images are left and right images.

- 20 Preferably the display means is for displaying alternately an approximately equal number of one or more horizontal lines of the first image and of the second image.

Preferably the imaging means is a stereo camera, a digital  
25 camera, a digital stereo camera, a video camera, a scanning laser ophthalmoscope or any other suitable imaging means that is able to record two different views of the object to be imaged.

30 Preferably the digitizing means is an image scanner that is able to digitize a slide film with high resolution, a digital camera, or any apparatus capable of producing or converting an image into a digital format.

35 Preferably the controller means is a computer or a microprocessor.

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Preferably the image processing means is custom software.

Preferably the image processing means uses colour matching and image registration methods for the correction of  
5 differences in colour, rotation, translation and scale, and/or includes means for changing image magnification in three dimensions and real time.

Preferably the methods includes a colour matching technique  
10 utilising a linear adjustment method to match the mean and standard deviation of each colour component, and an automatic or semi-automatic technique for rotation and translation effects.

15 Preferably the display means includes a video display monitor or the like.

Preferably the visualizing means includes a pair of Liquid  
20 Crystal Display goggles.

Preferably the goggles are Vrex wireless or 3-D Max goggles, and more preferably the LCD goggles are electronically coupled to the display means.

25 Preferably the result display means includes a polar graph centred on the optic nerve head.

The present invention still further provides an apparatus for visualizing three dimensional, recreated views of an  
30 object, including:

a stereo camera for obtaining first and second images of a stereo pair;

digitizing means for digitizing the first and second images;

35 image processing means for determining and correcting for colour, rotation, translation and scale differences between two different interlaced images of the

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same object;

controller means for converting the images into an interlaced image, in which an approximately equal number of one or more horizontal lines of the first and then of the second image are displayed alternately;

display means for displaying registered, interlaced images; and

visualizing means for visualizing the images in three dimensions.

Preferably the apparatus includes measuring means for measuring specific characteristics of the object, calculating means for calculating desired measurements of the object, and result display means for displaying the results of measurements.

Preferably the apparatus includes a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

Preferably said object may be any object in which three dimensional topographic data is desirable.

Preferably said object includes human or animal tissue.

Preferably said object includes an animal or human body part.

Preferably said tissue or body part is the fundus of the eye, specifically the optic nerve head region, or other ocular features of interest.

According to the present invention there is also provided a method for creating and visualising three dimensional images of an object including:

obtaining two images of the same object from different angles;

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digitizing said images;  
colour matching and registering the images;  
converting the two images into an interlaced  
image;

5 displaying the registered interlaced image for  
visualizing the image in three dimensions;  
measuring areas of interest; and  
calculating desired measurements of the object

10 Preferably the method includes comparing stereo pairs or  
sets of stereo pairs, or colour correcting and/or  
registering and displaying sequentially or flickering two  
or more stereo pairs in 3D to highlight change or  
differences in topography.

15 Preferably the method includes displaying the results of  
the measurements.

Preferably said digitizing is performed in high resolution.

20 In order that the invention be more fully understood, some  
preferred embodiments will be described, by way of example,  
with reference to the following drawings in which:

Figure 1 is a diagrammatic plan view of a system  
25 according to the present invention;

Figure 2 is an explanatory diagram illustrating  
the process of producing an interlaced image; and

Figure 3 is an illustration of a novel colour  
matching process according to a preferred embodiment of the  
30 present invention.

Referring to Figure 1, the first arrangement of an  
apparatus of the present invention includes a Nidek  
simultaneous stereo camera 1 and 2, for recording two  
35 different images 3 and 4, of the ocular fundus of patient's  
eye 9, taken from left and right viewing positions.  
Alternatively, the images may be captured on film and

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developed on photographic paper or slides, which may then be digitised for the controller means (see below) via a scanner, such as a Polaroid Sprintscan or the like.

5 An image file of digitized images 3 and 4 is generated and stored in the memory of a controller means in the form of an IBM compatible personal computer 5, although any appropriate computing system may be substituted. This image file is accessed via custom software. The left and  
10 right stereo images are converted by the software into a single interlaced image 6, in which every second line is captured from both images. Referring to Figure 2, image A and image B are combined to form a single image C (corresponding to image 6 in Figure 1) containing  
15 stereoscopic information. A horizontal line of pixels from image A is displayed as the first line of the interlaced image C, and a horizontal line from image B is displayed as the next line. Either image A or image B may be the left or right image. The process of capturing alternate lines  
20 of pixels from the two images continues until the completion of an interlaced image C. This image C, therefore, contains every second line of the right stereo image and every second line of the left image.

25 Liquid Crystal Display goggles 7 are then used to visualize the interlaced image 6 in stereo, on a display unit in the form of a computer monitor 8 or similar video display screen. The LCD glasses 7 may be electronically coupled to the display unit, such as with those made by 3DMax, or they  
30 may be a wireless version, such as Vrex wireless LCD glasses. The monitor 8 must be in interlaced mode, so that firstly, the odd numbered horizontal lines are written on the display monitor, and then the even numbered horizontal lines. When the odd numbered lines are displayed, one of  
35 the two screens of the LCD goggles is darkened, while the other remains clear. The observer views the image with the eye under the clear screen and sees the information from



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the odd numbered lines (image A). After all of the odd numbered lines have been written, the LCD shutter alternates the darkened and clear vision windows and the even numbered lines are written (image B). This process  
5 takes approximately fifty milliseconds, which is imperceptible to the human eye. The interlaced image C can then be visualised as a "virtual" stereo image and the topography of the optic nerve head can be perceived in three dimensions. An alternative embodiment would involve  
10 a number of three dimensional glasses being connected, or used, in parallel with the video display monitor, so that several people could simultaneously view the interlaced image.

15 A novel image processing technique is incorporated into the custom software of PC 5 to compensate for differences in colour matching, scale, translation and rotation between stereo image pairs, or sets of stereo image pairs. Figure 3 illustrates the technique through which colour matching  
20 is carried out. Linear adjustment is used to accommodate for differences in grey scale (colour) from one image of the same object to another. Linear adjustment of the input image 10, into the output image 14, occurs pixel by pixel, by calculation of the means and standard deviations from  
25 the reference image 12. For a grey scale image, this will simply adjust the mean and standard deviation of the input image to the mean and standard deviation of the reference image. For colour images, however, linear colour  
30 correction will be applied separately on each colour component of red, green and blue. The mean and standard deviation of each colour component of the input image will be appropriately matched to the reference image.

Image registration is also applied to compensate for  
35 translation, scale and rotation differences between stereo pairs or sets of stereo pairs. This may be completed via an automatic or a semi-automatic registration procedure.

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Two different techniques may be used to align sequential input and reference images. The first method provides automated and precise image registration based on a normalized grey scale correlation. In this method, feature matching is obtained in both the input and reference images, whereby the same feature in both images is identified. A unique template is automatically selected from the input image and a similar template is identified, if it exists, from the reference or target image. The reference image is then registered according to the differences in the centre coordinates of the templates. To reduce the search time, the search area on the target image may be limited to double the size of the template surrounding the centre of the template. The normalized grey scale correlation function reaches a maximum value of 1 when the input and reference image match exactly, or 0 when there is no correlation. By moving the template over the reference image, the correlation function is computed at each position. The position where the largest correlation value is obtained is considered the best match.

A second technique uses a semi-automatic method to register the stereo pairs. An even number of points from the input image and the approximately corresponding points from the reference image are chosen. The best possible match for the points chosen on the reference image is found. The search area is limited to the area surrounding the points selected on the reference image. This may increase the speed as well as the accuracy of the correlation computation. The differences in the x and y directions for each point (input and reference points) are computed and the average of the differences in the x and y direction obtained. This will correct for any translation differences.

By connecting two points and calculating the angles with respect to a horizontal axis in the input and the reference

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image, the difference in the angle can also be obtained. The average angle difference for all the pairs of points will give an estimation for the overall rotation of the reference image. This technique is faster than the  
5 automatic method, but the fully automatic method may provide more accurate alignment.

The apparatus of the present invention can also supply  
10 means to view, in real time, registered, stereo images of the same fundus in rapid sequence (stereo flicker chronoscopy). This technique allows comparison of two or three dimensional fundus images from the same patient, taken on different occasions. For example, a stereo pair  
15 photographed in 1995 may be registered with a stereo image taken in 1997. As the display jumps from one image to the other, subtle changes in the structure of the optic disc can be easily perceived. Flickering between a number of registered images may help the clinician visualize any  
20 changes in fundus topography over time.

A three dimensional mouse pointer can also be used to manually measure structures of the optic nerve head or other areas of interest. The three dimensional mouse  
25 pointer is an indicator which can not only be moved back and forth across the image plane on the monitor, but also perpendicular to that plane. Using a keyboard or other controls (not shown in Figure 1), the perceived depth of the pointer can be changed. This 3D mouse is valuable for  
30 measurements to be made or the precise location of objects or structures to be determined. It allows the cursor to be placed, in the eyes of the viewer, on the surface of the optic nerve or another three dimensional structure.

35 Measuring means, in the form of a circular or elliptic template, can then be displayed and positioned over the optic disc by the operator, to aid in obtaining

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measurements around the optic nerve head. Clinically important values regarding the extent of optic disc cupping and the width of the neuro-retinal rim can then be calculated. Differences in nerve-head rim measurements, between two chronologically separate images of the same fundus, can then be plotted in a polar fashion around the disc, with positive changes advancing beyond the edge of the disc and negative changes plotted towards the centre of the disc. A very good representation is thus displayed, allowing the operator to determine at a glance the size and position of any rim width changes. A quantitative measure of the change in optic nerve head rim measurements over time is therefore provided.

Thus, the present invention provides a novel system in which three dimensional images of an object may be constructed and analysed. Comparison between images taken at different times and at different orientations is possible using the present invention.

The advantages of the various embodiments of the apparatus and method of the present invention are thus that:

- stereo images can be seen on a screen, rather than the clinician having to bend over a light box;
- a series of stereo images can be flickered ("stereo flicker chronoscopy"), which is not possible using only the slides, and without using a mechanical system such as a Deltascope;
- the edges of the optic disc, the start of optic disc cupping and the start of the floor of the optic cup can be seen much easier than from monoscopic images;
- the high resolution allows precise location of the edges of the neuro-retinal rim;
- colour adjustment and correction minimize errors due to change in colour of photographs attributable to the photographic process, pupil dilation, and lens changes;
- the flicker system (chronoscopy) and the measurements

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system (chronometry) work together;

- registered and colour adjusted images are stored, and so do not have to be done over and over again; and
- a number of people can observe the stereo image on the computer screen simultaneously.

Modification within the spirit and scope of the invention may therefore be readily effected by a person skilled in the art. Other alternative embodiments would involve the use of one or two video cameras or a scanning laser ophthalmoscope to directly capture the image in a digital format. Any other single or stereo camera or imaging device that is capable of creating an image of the optic nerve head from two viewing positions, simultaneously or sequentially, may also be utilised. Thus, it is to be understood that this invention is not limited to the particular embodiments described by way of example herein above.

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## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A system for creating and visualising three dimensional images of an object, including:

5           imaging means for obtaining two images of the same object from different angles;  
          digitizing means for digitizing said images;  
          image processing means for colour matching and registering the images;  
10          controller means for converting the two images into an interlaced image;  
          display means for displaying the registered interlaced image; and  
          visualizing means for visualizing the image in  
15          three dimensions.

2. A system as claimed in claim 1, including measuring means for measuring areas of interest in three dimensions, and calculating means for calculating  
20          desired measurements of the object.

3. A system as claimed in either claim 1 or 2, including a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

- 25          4. A system for creating and visualising three dimensional images of an object, including:

          imaging means for obtaining two images of the same object from different angles;  
30          digitizing means for digitizing said images;  
          image processing means for colour matching and registering the images;  
          controller means for converting the two images into an interlaced image;  
35          display means for displaying the registered interlaced image;  
          visualizing means for visualizing the image in

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three dimensions;

stereo flicker chronoscope for comparison of  
stereo pairs or sets of stereo pairs;

measuring means for measuring areas of interest  
5 in three dimensions; and

calculating means for calculating desired  
measurements of the object.

10 5. A system as claimed in either claim 3 or 4, wherein  
said stereo flicker chronoscope is operable to serially  
display stereo pairs or sets of stereo pairs.

15 6. A system as claimed in either claim 2 or 4, wherein  
said measuring means is a three dimensional cursor.

7. A system as claimed in either claim 2 or 4, wherein  
said calculating means includes computer software.

20 8. A system as claimed in any one of the preceding claims,  
including result display means for displaying the  
results of the measurements.

25 9. A system as claimed in claim 8, wherein said result  
display means is a polar graph centred on the optic  
nerve head.

30 10. A system as claimed in any one of the preceding claims,  
wherein said imaging means is a stereo camera, a  
digital camera, a digital stereo camera, a video camera  
or a scanning laser ophthalmoscope operable to record  
two different views of the object to be imaged.

35 11. A system as claimed in any one of the preceding claims,  
wherein said digitizing means is a image scanner  
operabl to digitize a slide film with high resolution,  
a digital camera, or any other apparatus operable to  
produce an image in, or convert an image into, a

- 20 -

digital format.

12. A system as claimed in any one of the preceding claims,  
wherein said controller means is a computer or  
5 microprocessor.
13. A system as claimed in any one of the preceding claims,  
wherein said image processing means is software using  
the techniques of colour matching and image  
10 registration, and/or includes means for changing image  
magnification in three dimensions and real time.
14. A system as claimed in any one of the preceding claims,  
wherein said display means is a video display monitor  
15 or the like.
15. A system as claimed in any one of the preceding claims,  
wherein said visualizing means includes a pair of  
Liquid Crystal Display goggles.  
20
16. An apparatus for viewing three dimensional images of an  
object, including:  
imaging means for obtaining first and second  
images of a stereo pair;  
25 digitizing means for digitizing the two images;  
image processing means for determining and  
correcting for colour, rotation, translation and scale  
differences between different images of the same  
object;  
30 controller means for converting the images into a  
stereo interlaced image;  
display means for displaying registered  
interlaced images; and  
visualizing means for visualizing the images in  
35 thr e dimensions.
17. An apparatus as claimed in claim 16, including



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measuring means for measuring specific characteristics of the object, calculating means for calculating desired measurements of the object and result display means for displaying the results of measurements.

5

18. An apparatus as claimed in either claim 16 or 17, including a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

10

19. An apparatus for viewing three dimensional images of an object, including:

imaging means for obtaining first and second images of a stereo pair;

digitizing means for digitizing the two images;

15

image processing means for determining and correcting for colour, rotation, translation and scale differences between different images of the same object;

controller means for converting the images into a stereo interlaced image;

20

display means for displaying registered interlaced images;

visualizing means for visualizing the images in three dimensions;

25

stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs;

measuring means for measuring specific characteristics of the object;

calculating means for calculating desired measurements of the object and result display means for displaying the results of measurements.

30

20. An apparatus as claimed in either claim 18 or 19, wherein said stereo flicker chronoscope is operable to serially display stereo pairs or sets of stereo pairs.

35

21. An apparatus as claimed in either claim 17 or 19,

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wherein said measuring means includes a three dimensional cursor.

- 5 22. An apparatus as claimed in any one of claims 17, 19 or 21, wherein said measuring means includes a circular or elliptical template that may be superimposed over each optic disc, and which may be used to measure one or more parameters including neuro-retinal rim width and optic disc cupping.
- 10 23. An apparatus as claimed in either claim 17 or 19, wherein said calculating means includes computer software.
- 15 24. An apparatus as claimed in any one of claims 16 to 23, wherein said first and second images are left and right images.
- 20 25. An apparatus as claimed in any one of claims 16 to 24, wherein the display means is for displaying alternately an approximately equal number of one or more horizontal lines of the first image and of the second image.
- 25 26. An apparatus as claimed in any one of claims 16 to 25, wherein said imaging means is a stereo camera, a digital camera, a digital stereo camera, a video camera, a scanning laser ophthalmoscope or any other suitable imaging means that is able to record two different views of the object to be imaged.
- 30 27. An apparatus as claimed in any one of claims 16 to 26, wherein said digitizing means is an image scanner that is able to digitize a slide film with high resolution, a digital camera, or any apparatus capable of producing or converting an image into a digital format.
- 35 28. An apparatus as claimed in any one of claims 16 to 27,

- 23 -

wherein said controller means is a computer or a microprocessor.

- 5 29. An apparatus as claimed in any one of claims 16 to 28, wherein said image processing means is custom software.
- 10 30. An apparatus as claimed in any one of claims 16 to 29, wherein said image processing means uses colour matching and image registration methods for the correction of differences in colour, rotation, translation and scale, and/or includes means for changing image magnification in three dimensions and real time.
- 15 31. An apparatus as claimed in claim 30, wherein said methods includes a colour matching technique utilising a linear adjustment method to match the mean and standard deviation of each colour component, and an automatic or semi-automatic technique for rotation and translation effects.
- 20 32. An apparatus as claimed in any one of claims 16 to 31, wherein said display means includes a video display monitor or the like.
- 25 33. An apparatus as claimed in any one of claims 16 to 32, wherein said visualizing means includes a pair of Liquid Crystal Display goggles.
- 30 34. An apparatus as claimed in claim 33, wherein said goggles are Vrex wireless or 3-D Max goggles.
- 35 35. An apparatus as claimed in either claim 33 or 34, wherein said LCD goggles are electronically coupled to the display means.
36. An apparatus as claimed in any one of claims 17 or 19,

- 24 -

wh rein the result display means includes a polar graph centred on the optic nerve head.

37. An apparatus for visualizing three dimensional,  
recreated views of an object, including:

a stereo camera for obtaining first and second images of a stereo pair;

digitizing means for digitizing the first and second images;

image processing means for determining and correcting for colour, rotation, translation and scale differences between two different interlaced images of the same object;

controller means for converting the images into an interlaced image, in which an approximately equal number of one or more horizontal lines of the first and then of the second image are displayed alternately;

display means for displaying registered, interlaced images; and

visualizing means for visualizing the images in three dimensions.

38. An apparatus as claimed in claim 37, including measuring means for measuring specific characteristics of the object, calculating means for calculating desired measurements of the object, and result display means for displaying the results of measurements.

39. An apparatus as claimed in either claim 37 or 38, including a stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs.

40. An apparatus for visualizing three dimensional, recreated views of an object, including:

a stereo camera for obtaining first and second images of a stereo pair;

digitizing means for digitizing the first and

- 25 -

second images;

image processing means for determining and correcting for colour, rotation, translation and scale differences between two different interlaced images of the same object;

controller means for converting the images into an interlaced image, in which an approximately equal number of one or more horizontal lines of the first and then of the second image are displayed alternately;

display means for displaying registered, interlaced images;

visualizing means for visualizing the images in three dimensions;

stereo flicker chronoscope for comparison of stereo pairs or sets of stereo pairs;

measuring means for measuring specific characteristics of the object;

calculating means for calculating desired measurements of the object; and

result display means for displaying the results of measurements.

41. An apparatus as claimed in any one of claims 37 to 40, wherein said first and second images are left and right images.

42. An apparatus as claimed in any one of claims 37 to 41, wherein said object is any object in which three dimensional topographic data is desirable.

43. An apparatus as claimed in any one of claims 37 to 42, wherein said object includes human or animal tissue.

44. An apparatus as claimed in any one of claims 37 to 43, wherein said object is a human or animal body part.

45. An apparatus as claimed in any one of claims 37 to 44,

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wherein said object is an ocular feature such as the fundus of an eye or the optic nerve head region.

46. A method for creating and visualising three dimensional images of an object including:

obtaining two images of the same object from different angles;

digitizing said images;

colour matching and registering the images;

converting the two images into an interlaced image;

displaying the registered interlaced image for visualizing the image in three dimensions;

measuring areas of interest; and

calculating desired measurements of the object.

47. A method as claimed in claim 46, including comparing stereo pairs or sets of stereo pairs.

48. A method as claimed in claim 46, including colour correcting and/or registering and displaying sequentially or flickering two or more stereo pairs in 3D to highlight change or differences in topography.

49. A method as claimed in any one of claims 46 to 48, including displaying the results of said measurements.

50. A method as claimed in any one of claims 46 to 49, wherein said digitizing is performed in high resolution.

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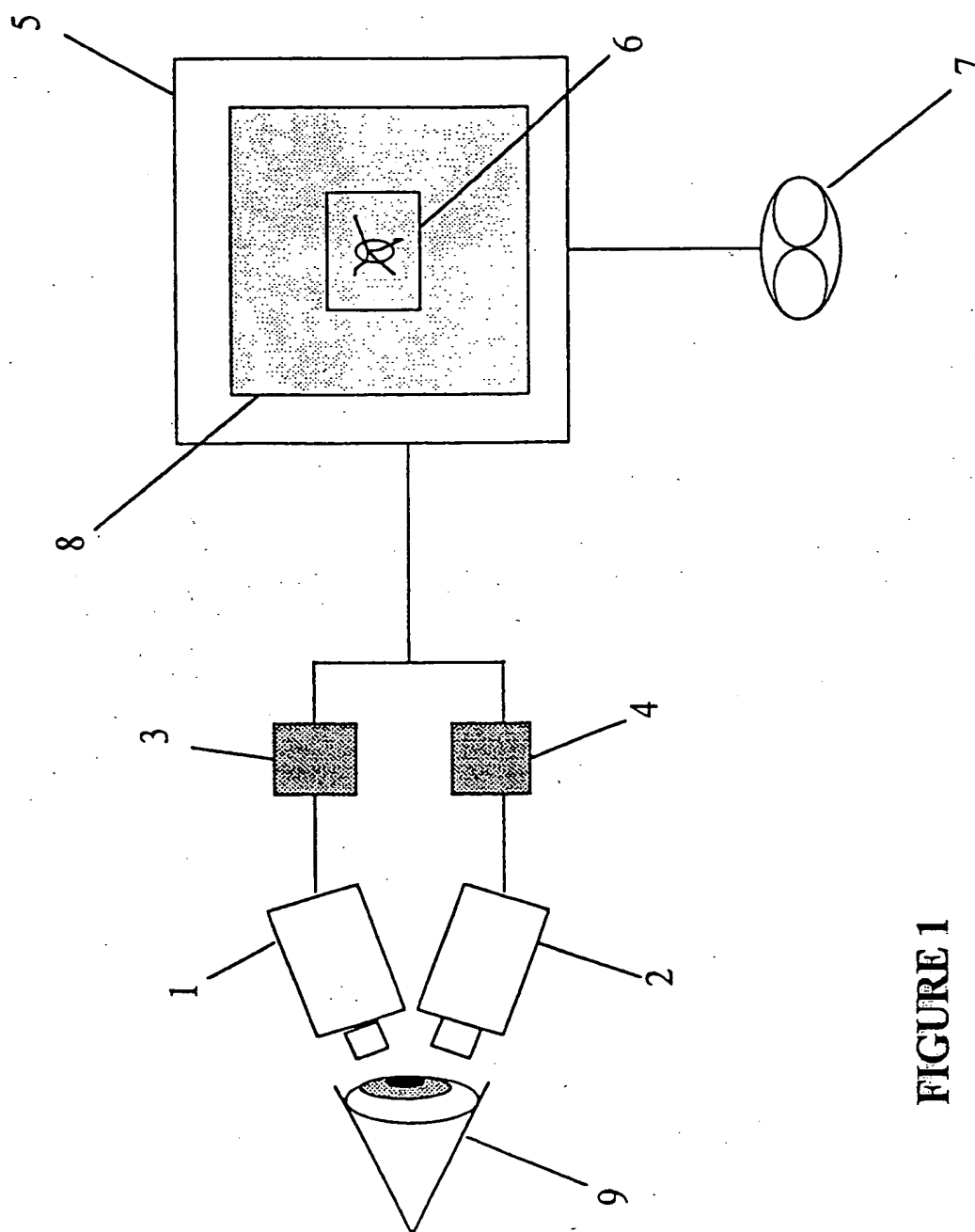


FIGURE 1

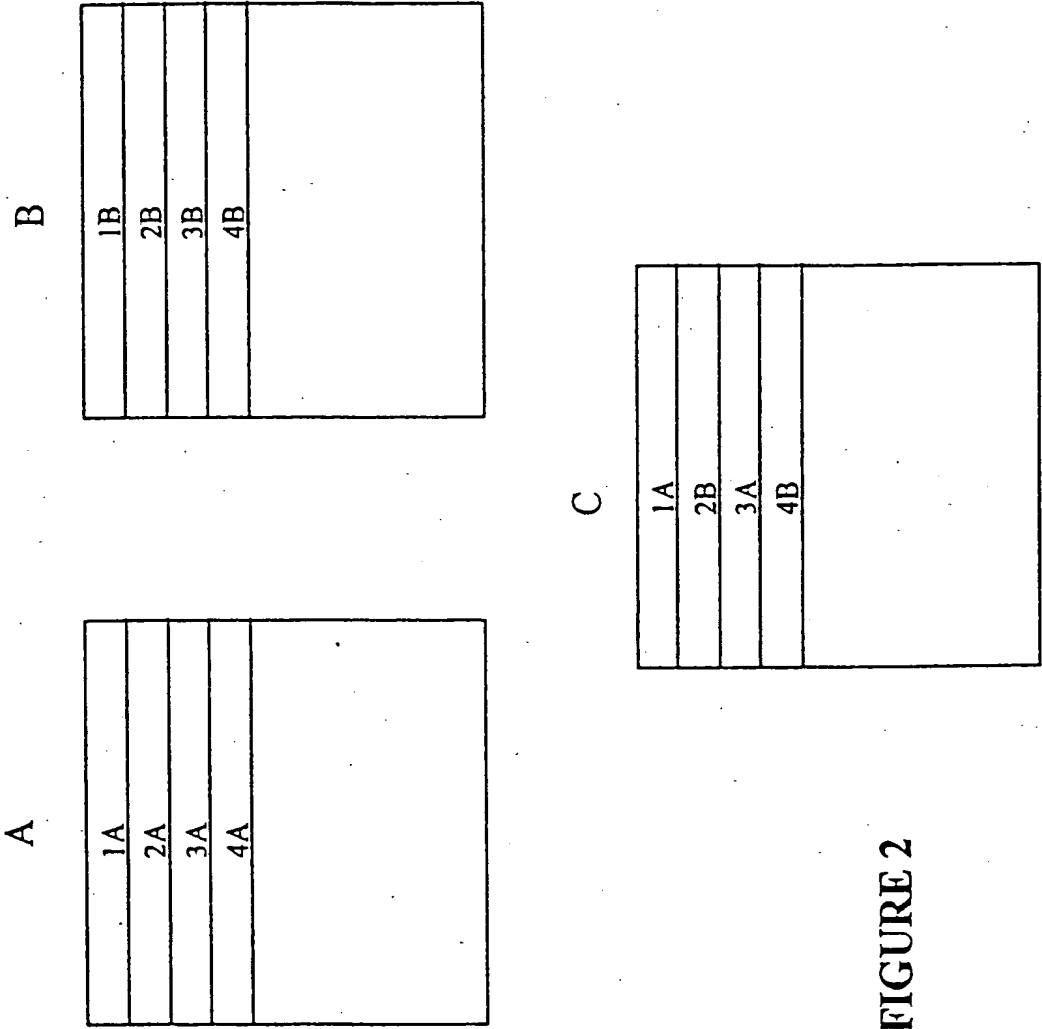
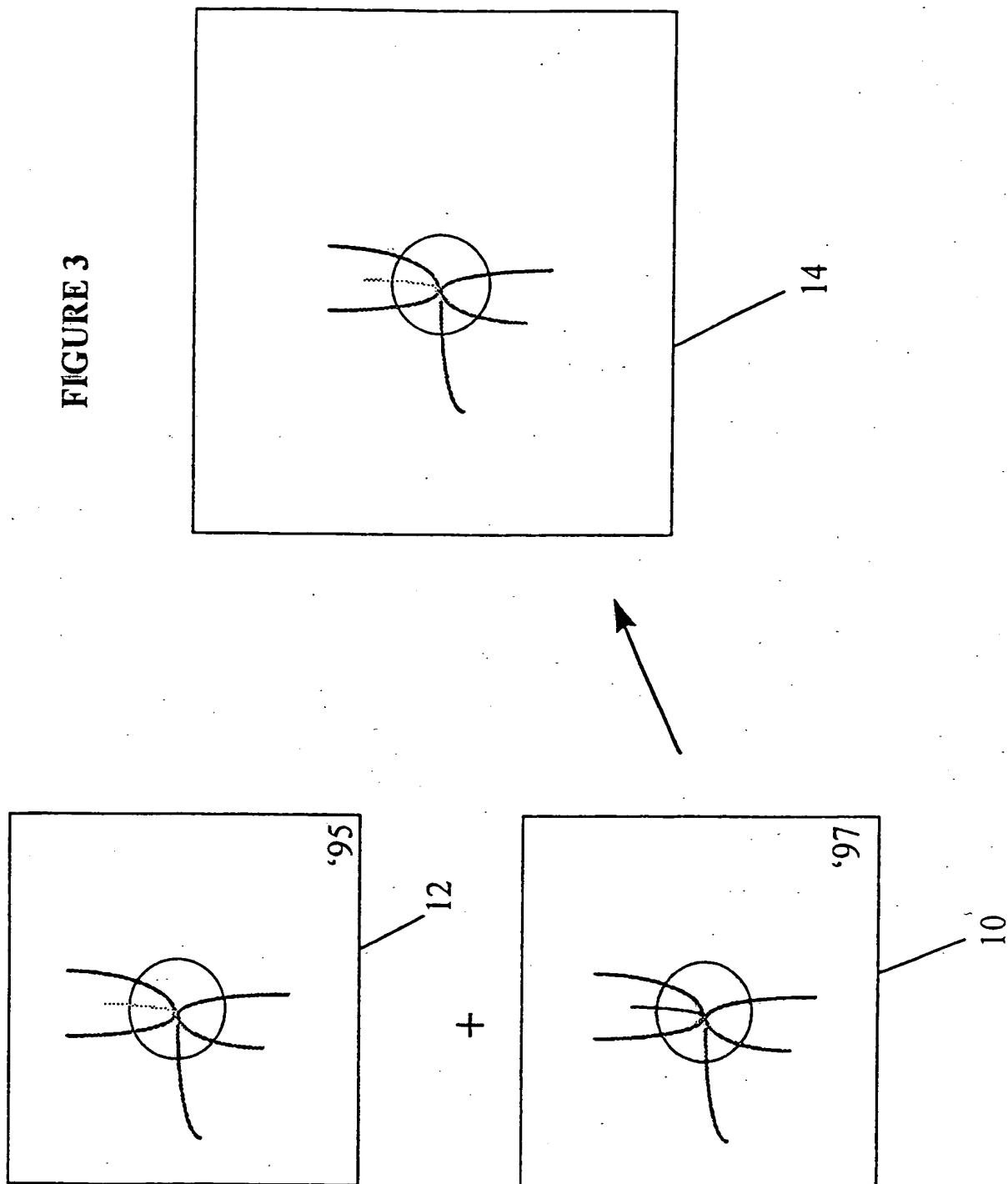


FIGURE 2



FIGURE 3



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/AU 98/00863

## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl<sup>6</sup>: H04N 13/02, 13/04, A61B 3/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC H04N 13/-, 15/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
WPAT, JAPIO: interlace

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 2268352 A (Hughes) 5 January 1994 Whole document	1,10-11,14-15 2,6-8,12-13, 16-17, 21,23-30, 32-35,37-38,41-44,46- 47,49-50
X Y	GB 2187912 A (SONY CORP) 16 September 1987 Whole document	1,10-11,14-15 2,6-8,12-13, 16-17, 21,23-30, 32-35,37-38,41-44,46- 47,49-50

☒ Further documents are listed in the  
continuation of Box C

☒ See patent family annex

<p>* Special categories of cited documents:</p> <p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" Earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>		<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>
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24 November 1998

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- 1 DEC 1998

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/AU 98/00863

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 2173667 a (NIPPON VICTOR KK) 15 October 1986 Whole document	1,10-11,14-15 2,6-8,12-13, 16-17, 21,23-30, 32-35,37-38,41- 44,46-47,49-50
X Y	US 5475419 A (Carbery) 12 December 1995 Whole document	1,10-11,14-15 2,6-8,12-13, 16-17, 21,23-30, 32-35,37-38,41- 44,46-47,49-50
X Y	EP 678832 A2 (Eastman Kodak Co.) 25 October 1995 Whole document	1,10-11,14-15 2,6-8,12-13, 16-17, 21,23-30, 32-35,37-38,41- 44,46-47,49-50

# INTERNATIONAL SEARCH REPORT

## Information on patent family members

International application No.  
PCT/AU 98/00863

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member		
GB	2268352	NONE			
GB	2187912	JP	62210797	US	4736246
GB	2173667	JP	61212190	US	4672434
US	5475419	AU	29107/95	WO	9601028
EP	678832	JP	8079797	US	5530774

END OF ANNEX